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PROJECT NUMBER NAS 5-22338

A REGIONAL LAND USE SURVEY
BASED ON REMOTE SENSING
AND OTHER DATA

"Made available under NASA sponsorship
in the interest of early and wide dis-
semination of Earth Resources Survey
Program information and without liability
for any use made thereof."

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Federation of Rocky Mountain States
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10 July 1975

QUARTERLY REPORT FOR PERIOD APRIL 10 - JULY 10, 1975

Prepared For

Goddard Space Flight Center
Greenbelt, Maryland 20771

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PREFACE

Objectives: To test and apply Landsat, other remote sensing and ground data, in an optimum mix for seasonal land use survey, for portions of the six member states in the region (Montana, Wyoming, Colorado, New Mexico, Utah, Arizona).

Scope of Work: Each state selected four 7½ min. USGS quadrangles as complete, diversified mapping areas. All states together adopted a 20-category table of land uses. The states are conducting field selection of each category of land use, as training sites for computer program calibration, signature analysis of Landsat tapes. The Federation's contractor, Colorado State University, will complete the signature analysis and run computer cellular maps at 2.5 acre cell size, covering all 24 target quadrangles. In addition to the Landsat source, it will be necessary to introduce other data from imagery and ground into the cellular map files for some or all quadrangles, at the States' options, to define Level II and Level III land uses. Ultimately, the procedure will be evaluated for feasibility of continuous application to portions or entire states.

Conclusions: This is the first 3-month report in an 18-month project, and therefor offers no reportable conclusions.

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INTRODUCTION

This is the first Quarterly Report in the 18-month scheduled project.

The project scope is complex and must be described in parallel roles of six state lead agencies, a technical contractor for extracting land use information from Landsat digital tapes, and the Federation as coordinator and demonstrator of multi-source and multi-purpose information procedure.

The technical responsibility of each member has been set forth in the Work Plan¹ dated January 1975. At present the actual progress along these paths may be gaged by the Work Schedule and Calendar, Figs 4 and 5.

In summary:

- Task I.A - Interstate workup conference - held
- Task I.B - Land use/cover categories - adopted
- Task I.C - Procure maps/photos - underway
- Task I.D - Landsat scene selection - underway
- Task I.E - Control points for rectification - underway
- Task I.F - Geometric Rectification - computer programmed but not implemented
- Task I.G - Select training sites - underway
- Task I.H - Los Alamos consultation - underway
- Task I.I - Interleave spectral bands, dates - not implemented
- Task I.J - Begin multi-source mapping - underway

Immediate efforts are focussed on getting multi-state performance in parallel, and securing the EROS materials. There are calendar lags in receiving the computer compatible tapes of Landsat imagery, and therefor in implementing the geometric rectification program. Also, there are lags in the state multi-agency working arrangements and the fieldwork in identifying and describing the training sites for signature analysis. However, the field work is underway and not in danger of missing the seasonal peak conditions of crops, forest and water phenomena - and the Fall season will provide adequate time for the Landsat signature analysis and geometric rectification.

¹See work schedule in Appendix hereto

MAIN TEXT

During the first quarter, the states agreed upon 23 of the 24 target areas for land use and cover mapping; these being standard U.S.G.S. map quadrangles of 50 sq. miles each, distributed in varying types of resources and landforms within the larger test areas, in six states. They also adopted a common test classification of land use and cover suitable for satellite sensing. They considered the problem of additional data sources and a computer compositing process to satisfy the many and varied user requirements.

The following paragraphs are extracted from the early reports and proceedings:

Each potential user or functional area, agriculture, natural resources, etc., needs its own best classification of relevant conditions of land. The problem is a "general purpose" system, built up from "elementary indicators", mixed into any complex description. Remote sensing can "see" only elementary indicators of certain kinds. It is equally important to use aerial photography, geological data, water data, industrial and urban data, etc. All these indicators, when mapped out in digital cells, will result in any desired combinations for functional or activity maps which are accurate and low in cost. This would define "Forest Grazing Area," "Open Pit and Strip Mining," "Parks and Recreation Areas," or other complex maps. The entire project attempts both the efficient application of satellite sensing and its efficient manipulation with other data, running through a cellular compositing hopper.

Rocky Mountain Landuse and Cover Categories for remote sensing recognition by the CSU RECOG model:

Residential	Marshlands
Industrial - Commercial	Brushlands
Deciduous Forest	Snow fields
Evergreen Forest	Bare lands
Mixed Forest (with decision rule)	Salt flats
Grassland - irrigated	Bare soil
Grassland - non-irrigated	Bare rock
Cropland - irrigated	Sand areas
Cropland - non-irrigated	Unclassified
Water - lakes, reservoirs, streams	
Water - shallow surface water	

The states have selected the following standard USGS 7½ min. quadrangles for full mapping of land uses and cover categories. The Landsat 2.5 acre cellular maps will be computer printed at the same scale of 1: 24,000, so that any USGS mapped features may be overlaid as transparencies. Various transparent prints must be obtained, such as the USGS topography, roads, water features, land survey lines, etc. - thereby offering any desired visual combination with the land use and cover from Landsat. It should be noted that the computerized cellular map printing process may also store, display and combine any other data, besides the Landsat source. Thus, the system will be versatile for storing and combining data.

Concerning the selection of mapping cell size, for the purpose of the project it has recognized that the "black boxes" - both RECOG and CMS - needed to focus on one basic cell size. It was agreed to start with the 2.5 acre unit, which is as small as practicable for interpreting the remote sensing picture elements, and which could later be aggregated up to 10, 40, 160 or 640 acres for any summary mapping.

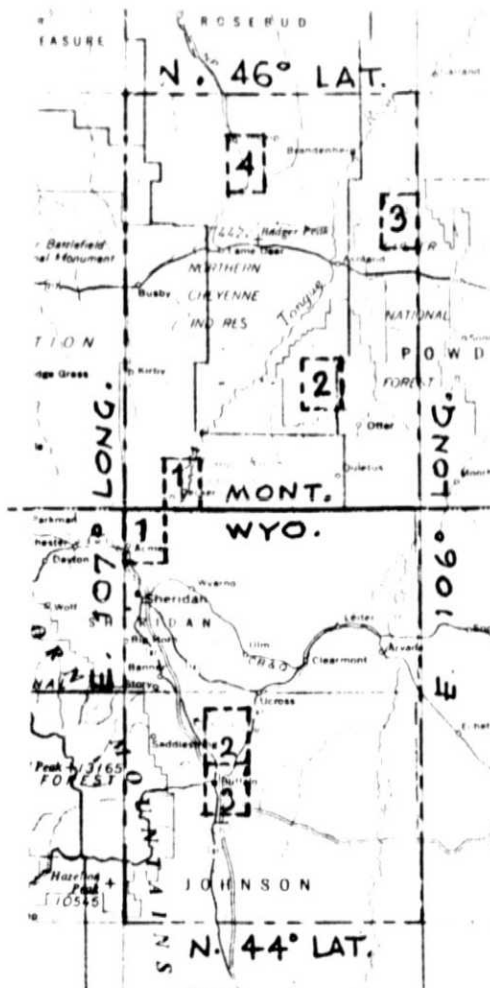
A basic problem has been that computer mapping programs were restricted to one or another type of hardware, making it difficult to interchange data tapes among states or agencies. CMS-I was one such program, running only on UNIVAC and CDC equipment. Therefore, the Economic Development Administration supported the Federation in converting it to CMS-II, which will operate on IBM and PDP hardware as well as CDC and UNIVAC.

The new CMS-II program is almost ready for distribution to the states, requiring only the Systems Manual and the User's Manual for completion in August.

The basic features of the CMS-II program are:

1. Small memory core requirements to reduce operating costs.
2. Compatible with CMS-I in input and output features.
3. Will accept both digitized polygonal input from other digitized mapping tapes, or any conventional maps or tabular data.
4. Internal storage of maps.
5. Symbol conversion from one legend to another.
6. Inter-map arithmetic compositing through addition, subtraction, multiplication or division point to point, map to map.
7. Inter-map logical compositing using Boolean functions.
8. Scaling and mapping of census data for tabular maps.
9. Frequency distribution or histogram output.
10. Aggregation of small cells into larger.
11. Numeric, greytone display, with boundaries.

MONTANA TEST SITE AND QUADRANGLES



1. Decker quad. Dry grass, coal stripping.
2. Poker Jim Butte. Forest service, grass and ponderosa development.
3. Beaver Creek School. Agriculture, grass, ponderosa.
4. Colstrip. Coal stripping, sub-irrigated agriculture, rangeland.

WYOMING TEST SITE AND QUADRANGLES

1. Acme quad. Coal stripping, grassland, range.
2. Lake de Smet. Coal, grassland, range.
3. Buffalo. Coal, grassland, range.
- 4.

COLORADO TEST SITE AND QUADRANGLES



1. Alamosa W. Urban, irrigated agriculture, pasture, recreation.
2. Manassa. Irrigated, range, recreation.
3. Fox Creek. Forest, grass, range, recreation.
- 4.

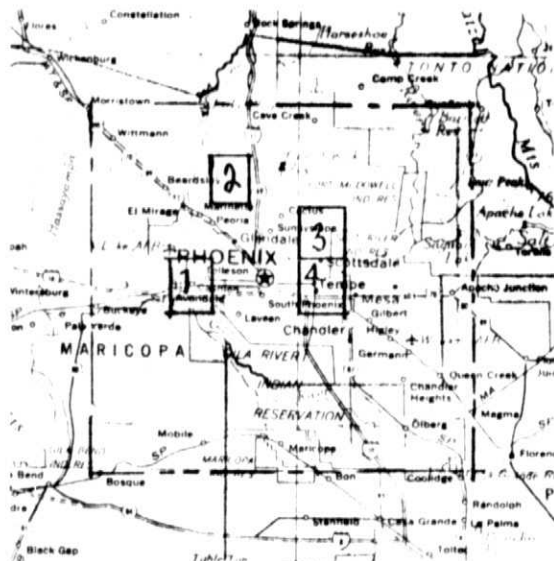
1. Questa. Mining, grass, range, forest.
2. Taos. Urban, irrigated, agriculture, grass, range.
3. Espanola. Mixed type agriculture.
4. Santa Fe. Urban, range, recreation.

NEW MEXICO TEST SITE AND QUADRANGLES



UTAH
TEST AREA AND QUADRANGLES

1. Mountaineer Quad. Forest, recreation, subdivision, urban.
2. Farmington. Urban, range, farming, fluctuating water.
3. Smithfield. Mixed agriculture, range, forest, urban.
4. Salt Lake City S. Urban, agriculture.



ARIZONA TEST AREA AND QUADRANGLES

1. Tolleson quad. Urban, irrigated agriculture, range.
2. Hedgepeth Hills. Irrigated agriculture, range, subdivision.
3. Paradise Valley. Urban, irrigated agriculture, range, recreation.
4. Tempe Urban, irrigated agriculture, range.
5. Chandler. Urban, irrigated agriculture, range.

NEW TECHNOLOGY

Although there is no specified "new technology clause" in this contract, this project will develop new technology for handling versatile inputs of data in addition to remote sensing input. Numerous potential users need more combinations of information on analytic maps than the Landsat and high altitude imagery can supply. In the attempt to reach these users, the project will exercise in some or all of the 24 quadrangles in the region a procedure for stacking numerous data items in addition to the remote sensing input. More particularly:

Data Source Mixing. The satellite data will be mapped out in 2.5 acre cells, for 19 land use and cover categories, at the scale 1:24,000. At this useful scale there is a good deal of conventional map data from the standard U.S.G.S. quadrangle mapping series - topography, water and streams, forest cover, urban and highway detail, etc. Also, the new ortho-photo quads supply much visual information suitable for more particular interpretation. Beyond these standardized U.S.G.S. variables there are many other sources covering: geology, hydrology, agricultural and forest data, soil suitability, crop and grassland conditions, populations characteristics and occupations, income, local industrial activity data.

Need for a suitable cellular system. The Landsat picture elements may be aggregated to any suitable cell pattern. The problem is to bring in all other map forms, scales, cartographic projections, and XY polygonal data into a uniform mapping process to achieve data mixing. There is another important objective: multi-variate analysis using the various maps on file, deriving statistical relationships or composite map models.

The main components needed for this technology are available. Some member states are already familiar with the CMS composite mapping system, and have made some applications to economic geography, environmental planning and land use planning at various scales. So far this technology has not been applied to building and running a generalized data system for land use and land cover. The present project presents this opportunity.

The next intended step in this technology is to supply each state with the new composite mapping program CMS-II plus technical assistance for cellularizing a number of variables in addition to the Landsat data. Arizona, New Mexico and Montana have already indicated their interest, and all member states may wish to do this.

The problem of computer time may have to be resolved by Los Alamos Scientific Laboratories where there is indication of willingness to contribute to this scientific development.

PROGRAM OF NEXT REPORTING INTERVAL

By reference to the Work Schedule and Time Sequence in the Appendix.

- (a) States will complete training site selection and definition of 1974-75 crops and dates of planting, peak growth and harvest.
- (b) Colorado State University will perfect the satellite signature analysis for the selected categories and will interleave the several dates of imagery for maximum discrimination.
- (c) All project members will review, modify and finalize the categories, in preparation for land use mapping of the entire quadrangle areas.
- (d) Los Alamos Scientific Laboratory will accomplish the geometric rectification of the satellite picture elements.
- (e) The states will continue work with potential users agencies for creating composite data files for sensitive land use description and analytic modeling in the quadrangle areas.
- (f) Colorado State University will begin to run complete land use and cover maps of the quadrangle areas.

Longer Term Schedule

By Mid-August (States)

- (a) Training fields for each land use category laid out on standard U.S.G.S. maps;
- (b) Mark the date of field identification for each target;
- (c) Indicate the 1974 crop or grass condition on each target;
- (d) Define the 1975 current crop or grass condition and:
 - (1) Approximately when the ground is normally worked for planting
 - (2) Approximately when the peak crop appears
 - (3) Approximately when it is harvested
 - (4) See also Remote Sensor 2!

By End-August (Colorado State University)

Drs. Miller and Maxwell at CSU have selected cloud-free Landsat tapes for 1974 and are working on 1975 imagery as it becomes available. These tapes will include spring, summer and fall coverage, so that the multi-spectral signals for each picture element can be interleaved for sharper identification of land use. Given the state-selected training fields, they will calibrate these signals on each target area, and report to the States.

Fall 1975 (States and CSU)

The state lead agencies will field check the accuracy of the resulting Landsat. To aid in this, by the end of August they will have the new U-2 color infrared transparencies. After any necessary corrections in Landsat tape interpretation, CSU will proceed to map out the land use and cover of all twenty four quadrangles in the region (four in each state).

Winter and Spring 1976

The lead agencies may set up with their user groups cellular compositing to bring in sources other than satellite data, including agricultural and forestry production data, hydrology data, recreation data, economic factors, ownership and land assessment information, etc. By this time the CMS-II cellular mapping program will be available to fit any state computer installation. Also, Los Alamos will have CMS-II running and may offer compositing demonstrations at nominal cost. This phase will demonstrate to potential user the versatility of a state information system for land use and related data.

CONCLUSIONS

- A. The intended scale of this project is regional, multi-county, multi-state and federal. This leads to problems of inter-agency cooperation, time consuming administrative problems outside of the scientific purposes of the project. Although it seems readily possible to achieve a short term demonstration, using ad-hoc cooperation of the agencies, beyond this lies the need and the capability of a long-term continuous data service covering regions. The mix of federal and state responsibility remains to be defined, with the help of this project.
- B. State Lead Agencies are discovering the internal state difficulties of inter-agency participation.
- C. Federal agencies such as BLM, Bureau of Reclamation, Forest Service, Agriculture could become members in areas of high federal land proportion and management. Generally, federal agencies are better stocked with data, and inclined to systematic improvements in survey procedure.
- D. There is a related purpose in this project - to achieve acceptable inter-state land use survey categories. At present, all states are using the same table of land uses and cover categories, for this satellite application, with the understanding that any desired finer state variations could be added by them in time. Thus, there is a possibility that an inter-state survey table might continue at the first and second level of land use detail. This would be of particular interest to the federal agencies.

RECOMMENDATIONS

These recommendations concern project management within the region, and do not imply any change in the NASA supply of imagery.

State lead agencies should begin to look beyond the Landsat source of land use information to other sources needed to create a wider and deeper land use survey system, to answer the working questions of various users. This process may be expedited with the use of CMS (composite mapping system using a cellular grid of 2.5 acres), which is currently being adapted for this purpose by The Federation and the U.S. Department of Commerce.

Each lead agency should work closely with an inter-agency project committee to (1) complete the field work on training site, (2) expand and refine the land use categories according to various agency interests, and (3) start preparing composite mapping demonstrations.

APPENDICES

APPENDIX A.....Work Schedule for NAS

APPENDIX B.....Scope of Regional Information System

APPENDIX C.....Complementary Projects

APPENDIX D.....Attendees at Joint Ad Hoc Committees on
Earth Resources Technology

Work Schedule for NAS 5-22338

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
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DATA PROCUREMENT AND DATA PREPARATION

(I.A) Convene all participants for review & training sessions. Throughout the project:	(I.A) Review and training	(I.A) Participate in the initial training session	(I.A) Preside and participate in the first general review meeting. (Throughout the project provide review and advice for scientific and policy matters.)
<ul style="list-style-type: none"> - provide quarterly reports to NASA, states - review progress - fiscal control - coordinate makeup plans - state, CSU and LASL coordination in technical work - technical assistance to states in establishing wider survey system 			
	(I.B) Define the preferred land use classification system in 1st & 2nd order, adapt to test areas & the state planning & analytic purposes of a data system		

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State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
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(1.C) Procure maps,
air photos,
high altitude
data for test
sites

(1.D) Procure remote
sensing imagery
of test sites
for series of
dates

(1.E) Determine map
control points
for sites for
geometric
rectification
of remote
sensing imagery

(1.F) Rectify
appropriate
portions of each
original ERTS-
computer
compatible tape
(CCT) to
conform to 1.E

(1.G) Select land
use identifica-
tion sites
(jointly)

(1.G) Select most
significant
land use
classes for
training
sites, for
computer
image process-
ing

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State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint Efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	Ad Hoc Committee on Earth Resources Technology Applications
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- (I.I) Combine rectified
ERTS-CCT onto a
single tape for
each site:
1. continuous segments
of each site from
rectified images
 2. each spectral band
from each date will
be interleaved

(I.H) Consultation
and assist-
ance on
rectification
procedures

(I.J) Work with CSU and
LASL to integrate
cellular system for
wider scope data
files & compositing
analysis

(I.J) Work with FRMS
& CSU to set up
a demonstration
of a cellular
interchangeable
mapping system
for a wider
scope of informa-
tion, accepting
any raw data form

(I.J) Advise on purposes
& characteristics
of a regional
cellular mapping
system

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State Lead Agencies

Colorado State University

Federation of Rocky Mountain
States (FRMS)

Joint Efforts
States, CSU,
FRMS and LASL

Los Alamos Scientific
Laboratory (LASL)

Ad Hoc Committee on
Earth Resources
Technology Applications

LAND USE CLASS IDENTIFICATION PROCEDURE

(11.1) Provide
available information
on geology, soil,
topography, etc., for
study of effects of
land use on scientific
sensing, for 11.C

(11.5) Statistically analyze
& characterize land
use readings, in order
to:

- 1. recognize erroneous
data in the
training fields
- 2. determine clear
separations
between classes

(11.6) Analyze effects of
extraneous variables
(i.e., geology,
soils, slope, etc.)
on interpretation of
and use classes

(11.6) Field or
photo-check
anomalous portions
of training sites
(those statisti-
cally inconsistent
from CS, analysis
task 11.E & 11.C)

(11.6) Analyze & correct
the remote sensing
readings for new
modified land use
classes

(11.7) Convene all
participants for
stage agreements

(11.8) Determine most
practical cell
sizes for the
several purposes
of the project
& future
system applica-
tions, develop
the LASL
approach to
multi-factor
mapping

(11.9) Determine
scope of socio-
economic or resource
topics for analytic
mapping, beyond the
ERTS land use range.
Determine best
sources & needed
state inputs.

(11.10) Review Meeting #2

(11.1) Modify
training sites
& land use
classes as
needed before
final review
of land use
identification

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LAND USE MAPPING IN THE TARGET QUADRANGLES

- | | | | | | |
|--|---|---|--------------------------------|---|---------------------------|
| III.A) Select four 7 1/2 minute quadrangle map areas within the test sites in each state for detailed ERTS tapping | (III.B) Aggregate the ERTS picture elements into larger cell sizes (i.e., 10 or 40 acres) as jointly determined | (III.H) Convene all participants for stage agreements | (III.H) Review output products | (III.C) Consultation and assistance on cell aggregation procedures, appropriate for the test data file extending beyond ERTS land use classes. | (III.H) Review meeting #3 |
| III.D) Collect additional needed and/or desired data for the quadrangles for verification & analysis purposes as well as cost/time information on data preparation | III.E) Identify land uses in all cells in the selected map quadrangle areas | | | (III.I) Obtain ERTS land use outputs and other state inputs for demonstration of "mixed" data analysis & composite mapping for states' selected planning objectives | |
| III.G) Evaluate the accuracy of the land use overlays prepared from the ERTS source | III.F) Prepare transparent computer land use classification overlays of the selected quadrangles | | | | |

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TECHNOLOGICAL ASSESSMENT OF RESULTS, AHN COMPARATIVE EFFICIENCY AND COSTS

(I.A)
Provide further
analysis
and comments

(IV.B)
Examination and assessment
of classification errors

(IV.C)
aid states and LASL in
further analysis
possibilities

(IV.D)
Comparison of ERTS land
use classifications
with other methods

(IV.E)
Provide cost/information
tradeoff analysis

(IV.G)
Identify needed R & D
and future capabilities
of ERTS land use
information

(IV.H)
Evaluate ERTS
land use
survey system
and its
contribution
to general
area analysis
relative to the
LASL demonstra-
tion

(IV.F)
Produce composite
mapping simulations
& analysis as per
state guidelines

(IV.H)
Evaluate ERTS land use
survey system and its
contribution to general
area analysis relative
to the LASL demonstration

(IV.H)
Evaluate ERTS
land use
survey system
and its
contribution
to general
area analysis
relative to the
LASL demonstra-
tion

State Lead Agencies	Colorado State University (CSU)	Federation of Rocky Mountain States (FRMS)	Joint efforts States, CSU, FRMS and LASL	Los Alamos Scientific Laboratory (LASL)	An Ad Hoc Committee on Earth Resources Technology Applications
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PREPARATION OF FINAL PRODUCTS

(V.A) Prepare any additional input for final report	(V.B) Prepare final forms of computer images and printed overlays. Draft Technical Report & Users Report on ERTS applications	(V.D) Convene participants in a final evaluation and procedure workshop	(V.D) Review and evaluate products & results - review draft of final report - determine further efforts	(V.C) Prepare final output & contribute to the general report on techniques and results	(V.D) Preside over review meeting and workshop
(V.E) Participate in general report	(V.E) Participate in General Report	(V.E) Coordinate the prepara- tion of the General Report on both ERTS & larger scope data system including the socio-economic and resource mapping of LASL			

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SCOPE OF REGIONAL INFORMATION SYSTEM

Landsat Demonstr. List

Residential
Comm-indust.
Forest Types
Grassland Types
Cropland Types
Marshland
Water Areas
Barrenland
Snow Cover
Barrenlands
Swamps

Other Basic Physical Surveys

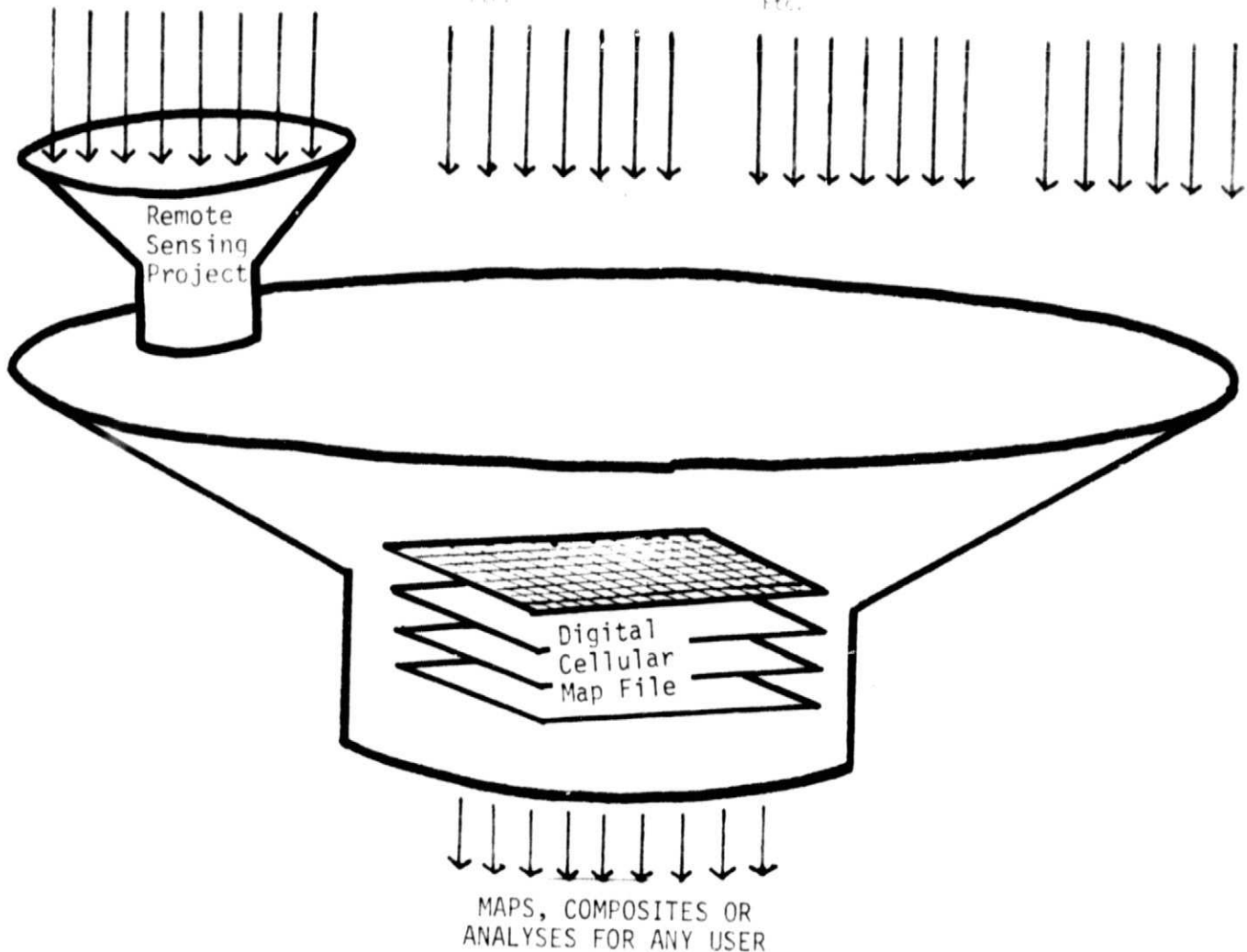
Soil Fertility
Precipitation
Groundwater
Crop Production
Irrigation Levels
Forest Surveys
Geological, Mineral
Levels of Mining Activity
Wild and Game
Land Assessments
Etc.

Socio-Economic Area Data

Population
Growth
Composition
Employment
Occupation
Income
Vital Statistics
School Statistics
Recreation Statistics
Sales Statistics
Etc.

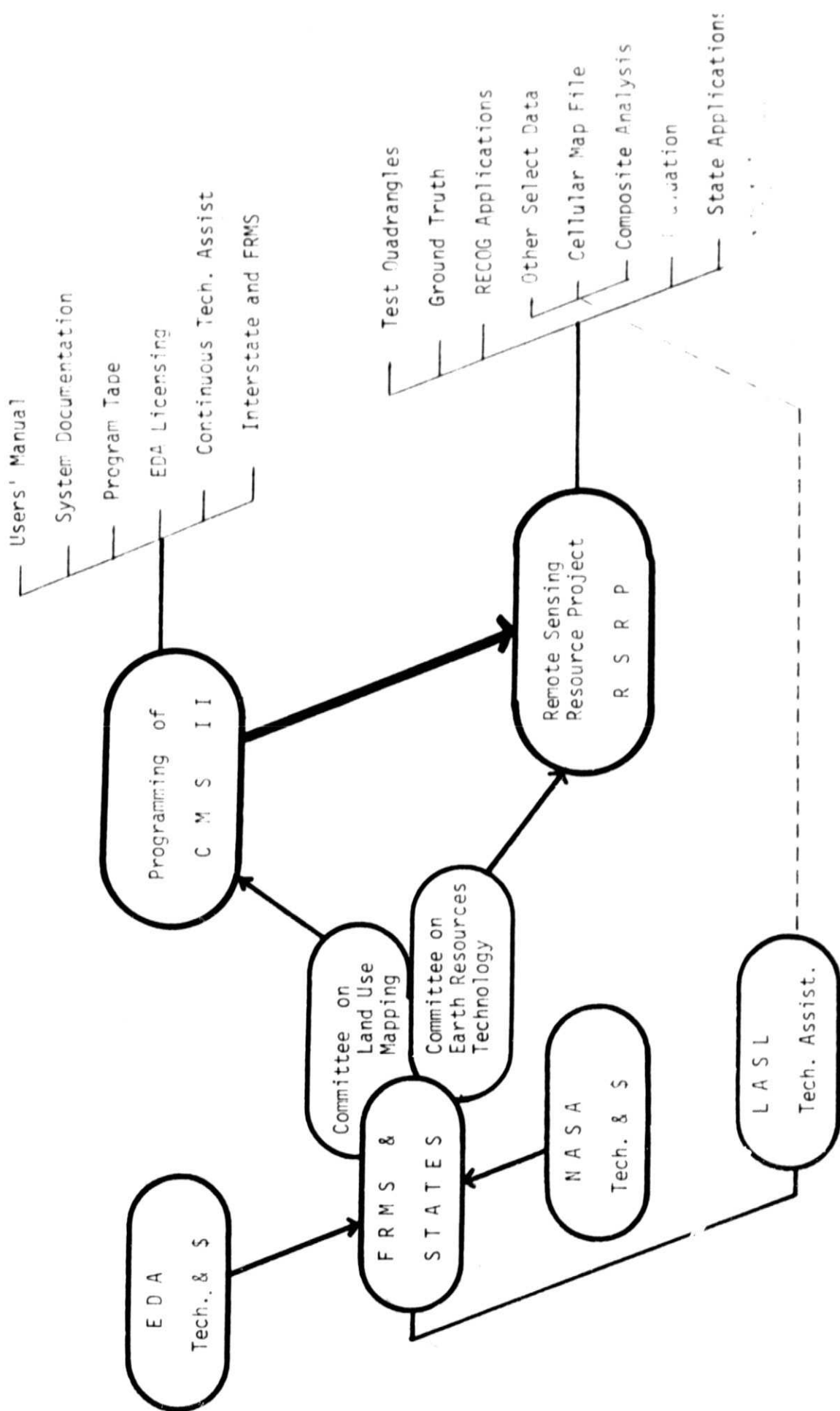
Local Spot Information

Area Zoning
Adviser Filings
District Boundaries
Service Zones of
Utilities
Service Zones of
Schools, Hospitals, Etc.
Highway Corridors,
Capacities, Loads
Planned Areas for
R&D Areas



COMPLEMENTARY PROJECTS

Federation of R. M. States - Conference April 7, 8, 9



REGENCY INN
Denver, Colorado
April 8 and 9, 1975

FRMS, Denver, Colorado
BLM, Denver, Colorado
Boise, Idaho
Geography Dept. Univ. Utah
Energy Planning, Helena, Montana
Cheyenne Light, Fuel & Power, Wyo.
Bur. Business Research, Univ. Utah
FRMS, Denver, Colorado
Colorado Div. Planning, Denver
Geography Dept. Univ. Idaho
Colorado School of Mines, Golden
Public Service Co., Colorado
FRMS, Denver, Colorado
LASL
LASL
LASL
LASL
Information Systems Div., Montana
Technology App. Center, New Mexico
FRMS
FRMS
DEPAD, Cheyenne, Wyoming
BLM, Cheyenne, Wyoming
LASL
Earth Resources, Colorado State Univ.
Dept. Civil Engineering, CSU
USGS, Denver, Colorado
EROS Data Center, Sioux Falls, S.D.

